

2009

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Harminder Singh

Michigan State University, singh@bus.msu.edu

Matt Wimble

Michigan State University, wimble@bus.msu.edu

V. Sabamurthy

Michigan State University, sabamurthy@bus.msu.edu

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Recommended Citation

Singh, Harminder; Wimble, Matt; and Sabamurthy, V., "The Influence of Industry Growth and Firm Market Share on Firm-Level IT Value" (2009). *AMCIS 2009 Proceedings*. 730.

<http://aisel.aisnet.org/amcis2009/730>

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The Influence of Industry Growth and Firm Market Share on Firm-Level IT Value

Harminder Singh

Michigan State University
singh@bus.msu.edu

Matt Wimble

Michigan State University
wimble@bus.msu.edu

V Sambamurthy

Michigan State University
sambamurthy@bus.msu.edu

ABSTRACT

Market-dominant firms traditionally have an advantage in growing markets because they operate with larger average plant sizes and are better able to reap the rewards of economies of scale. We present evidence that with information technology (IT), the effect is precisely the opposite: firms with less market power enjoy the benefits in a growing market. The influence of firm-level attributes on the economic value of information technology (IT) to firms has been the predominant focus of much prior research in this field. While some studies have examined how IT value differs across industries, there has been little research on how industry and firm attributes *jointly* affect firms' returns on their IT investments. To that end, we develop cross-level hypotheses to examine how the latter is influenced by industry growth and firm size. By using a hierarchical linear model to test the industry-to-firm interactions, we are able to control for violations of statistical assumptions that are likely to bias cross-level estimates obtained using conventional statistical methods. Results of the analysis reveal that 93.25% of the variance in firm-level IT value lies within firms, while 6.75% is attributable to industry-level factors. The implications of these findings for research and practice are examined.

Keywords

Information technology and firm performance; business value of information technology; industry effects; hierarchical linear modeling

INTRODUCTION

Information technology (IT) has become an important component of the production process for many firms and now represents the single largest category of capital investment in the United States (Stiroh 2002). The impact of this spending on various measures of firm performance, such as labor productivity, profitability and market valuation, has been studied by many researchers (e.g. Jorgenson 2001, Triplett and Bosworth 2002, Bharadwaj et al., 1996, Brynjolfsson and Hitt, 1996, Hitt and Brynjolfsson, 1996, Morrison, 1997; Anderson, Banker and Ravindran, 2006; Aral & Weill, 2007; Stiroh, 2002; Pilat 2004). The majority of these studies have also examined how firm-specific attributes, such as complementary organizational practices and IT capabilities (Rai et al 2006, Barua et al. 2004, Banker et al. 2006, Pavluo and El Sawy 2006), affect IT value.

In contrast, the impact of industry attributes has been largely under-explored. In their review of IT value research, Melville et al., (2004) ask: "What is the role of industry characteristics in shaping IT business value?" This relationship is worth studying as it reflects underlying differences in how similar inputs are used across different industries. Anecdotal evidence and practitioner studies indicate that industries differ in the extent to which they adopt and use IT, as well as the effectiveness with which they leverage IT functionalities and capabilities (e.g. Farrell, 2003; Forman, et al., 2003). These distinct characteristics lead to differences across industries in the impact of IT on performance measures, such as total factor productivity (Basu and Fernald, 2006). This is a corollary to research in strategic management, which has found that a firm's performance is significantly affected by its membership in a particular industry (Brush et al., 1999; Chang and Singh, 2000; McGahan and Porter, 2003).

A separate, but related, issue is how the impact of industry characteristics should be assessed. Prior research has handled industry heterogeneity in two ways: by using a) industry *dummies* (e.g. Aral, Brynjolfsson & Wu, 2006), or b) industry

attributes, such as capital intensity, concentration, and competitiveness (e.g. Chari, et al. 2008; Melville, et al. 2007), as *controls*. These methods are not viable means of understanding the relationship between industries and firm-level IT value because of the nested structure of firms within industries. Firms within particular industries tend to be more alike other firms in the same industry, compared to other firms in different industries. Thus, to prevent ecological bias (Thorndike, 1939; Robinson, 1950), where inferences about individuals (firms) are made from studies of groups (industries), studies of IT value should separate out the variance in the data due to membership in a particular industry from the firm-specific variance. Not doing so would lead to the underlying relationships between industry attributes and firm-level IT business value being misconstrued.

This study aims to address these gaps in our knowledge by focusing on the combined impact of industry growth and firm size on firm-level IT value. While large firms usually possess the slack resources and economies of scale to take advantage of technological advances, i.e. obtain more value from their IT investments, this may not hold true in fast-growing industries. In such industries, the existing (legacy) IT base of large firms would increase their switching costs of adopting new technologies. Hence, smaller firms would be able to adopt newer IT much more easily in growing industries, and thus, obtain more value from their IT investments. The research questions are: a) does IT provide greater value to firms in growing industries compared to firms in slow-growth industries? and b) does this impact differ across firms of varying sizes?

This study contributes in three ways. First, two research streams on IT value (industry-level and firm-level) are simultaneously considered and integrated. This is an important addition to the IT value literature and should improve our understanding of the impact of IT investments on firm performance. Second, specific cross-level explanations for IT value are put forward. Managers often use industry norms as a basis for their decisions, but have to adapt those norms to the circumstances of their specific firm. The cross-level explanations provided here, although limited to a few variables, can potentially help explain firm IT investment behavior better. Third, the cross-level analysis of IT value is carried out using hierarchical linear modeling (HLM) (Raudenbush & Bryk, 2002), an analytic method that is expressly designed to estimate models with nested data structures. Thus, ecological bias is removed as a potential explanation for the findings on IT value. HLM allows the variance found in the dependent variable to be partitioned across multiple levels of analysis, while taking into account differences in sample size and variance among different elements grouped within a given hierarchical level.

We next present the details of our model and hypotheses, followed by the description of the data, the analysis procedures and the results. The paper concludes after a discussion of the implications of the results.

MODEL AND HYPOTHESIS

Systems theory posits that focusing on either firm or industry attributes alone will not be as valuable as examining their interactive effect. This is because managers make decisions in particular contexts, indicating that the attributes of each level (firm and industry) are interdependent (Short, Ketchen, Palmer, and Hult, 2007). Industry matters in two broad ways for explaining how the impact of IT differs between industries: a) it sets out the social norms as to what IT to invest in, and b) the various industry attributes moderate the impact of firm-level characteristics on IT value. Thus, IT-related decisions made by firms' managers reflect in some fashion the social and cognitive influences of the institutional settings in which they are located (Chiasson & Davidson, 2005). For example, decisions to adopt collaborative IT, such as RosettaNet, Wi-Fi, EBPP, and XBRL, are affected by the level of network externalities related to these technologies (Kauffman and Li, 2003).

Beyond industry practices and norms, researchers should focus on identifying the particular mechanisms through which IT provides a payoff by integrating industry and firm attributes. This requires going beyond traditional explanations of IT's impact, such as capital deepening (for labor-intensive industries) and technical progress (for the computer-producing and durable goods sectors) (Dedrick, Gurbaxani & Kraemer, 2003). In that light, this study examines how industry growth influences the impact of a firm's market-share on the value it receives from its IT investments (Figure 1).

In growing industries, a firm's speed of response is important and developing these "sense and respond" capabilities (Sambamurthy & Zmud, 2000) will help enhance its agility. IT is often used to enable such capabilities, such as environment scanning, customer recruitment, and sourcing from spot markets. In contrast, IT's impact in slow-growth industries is often more on cost containment than revenue enhancement. Thus, the first hypothesis is that:

- H1: The higher the growth rate of an industry, the stronger will be the impact of IT investments on the performance of firms in that industry.

A firm's market-share indicates its market power and provides economies of scale benefits (Capon et al. 1990), and has been found to affect its performance. This applies to obtaining benefits from IT investments, too, as firms with a larger market-share possess the necessary slack resources to undertake corporate-level strategic IT actions, as well as being able to spread

out the costs of these investments over a larger scale of production. Thus, *ceteris paribus*, we expect firms with a high market-share to obtain more value from their IT investments.

However, this relationship may be modified by the level of industry growth. Industries with higher growth rates have lower levels of competitive rivalry, since new firms can take advantage of the increasing market size without having to compete with existing firms. The expanding market may encourage older firms, i.e. those with the larger shares of the market, not to invest in new technology, as they are doing well without such investments. The lower level of rivalry makes it easier for new firms to enter the market. Compared to the existing firms, new firms will be more willing to invest in IT so that they will be able to ramp up their economies of scale to support increased transaction volumes (Kobelsky, et al., 2008).

In addition, newer firms will not be faced with the switching costs associated with transitions out of less efficient legacy technology, making them more likely to have more up-to-date technology (Akeson and Kehoe, 2007). Conventional wisdom says that, while large firms have the advantage in a growing market, smaller firms gain in a shrinking market. Large firms have a larger average plant size and greater economies of scale, enabling them to expand production quickly. When markets shrink, the fixed cost/variable cost ratio rises faster for large firms than small firms. The opposite is true in growing markets: the fixed cost/variable cost ratio does not fall as fast for smaller firms (Ghemawat and Nalebuff, 1990). But, with IT capital, this conventional wisdom is turned on its head: in a growing market, smaller firms are able to switch to new technology, because they have lower switching costs. Thus, smaller firms can lower their fixed costs quicker than large firms. Thus, IT gives smaller firms an advantage in growing markets (Atkenson and Kehoe, 2007). These switching costs comprise the costs of learning the knowledge needed to utilize the new technology, and the costs of redesigning plants to take advantage of the new technology (Akeson and Kehoe, 2007). These switching costs make existing firms less agile, compared to new firms, as they persist in using their standard operating procedures and routines. Thus, the second hypothesis is:

- H2: In growing industries, the impact of IT investment on firm performance is stronger for firms with a low market share.

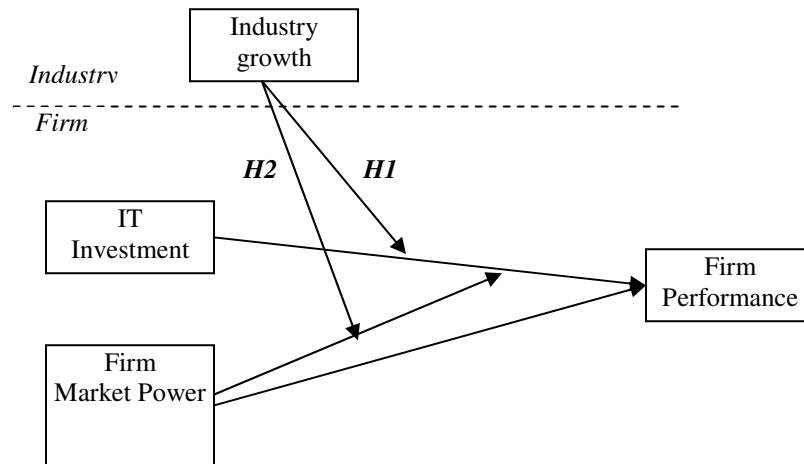


Figure 1. Research Model

METHODS

We used hierarchical linear modeling (HLM) (Raudenbush & Bryk, 2002) as it is recommended for analyzing nested data. HLM is useful for nested data because it helps overcome: a) aggregation bias, when a variable has different meanings at different levels, b) misestimated errors, which occur because observations at different levels are not independent, and c) heterogeneity of regression, where relationships between level 1 units differ across level 2 units (Mithas et al., 2006-7). In our context, firms (level 1 units, in HLM terminology) are nested within industries (level 2 units); this implies that within-industry (i.e. across-firm) variation in performance must take into account industry membership. Standard OLS regression, on the other hand, assumes that the effect of IT on firm performance and the mean level of performance are identical across industries. HLM provides an estimate of the variance in firm performance connected with between-industry differences in

attributes, such as concentration and capital intensity. This is not possible when industry summary statistics of these attributes are used as outcomes in standard ANOVA or regression models as controls.

Data and Variables

Data on the IT investments of 1413 firms from 1998 to 2004, together with accounting data, is used to test our hypotheses. The firms were part of 290 industries. The IT investment data, comprising details on IT budgets, the number of IT employees, and other IT-related information, is obtained from a survey of IT executives carried out by *Information Week*, while the accounting data is from Compustat. The *Information Week* data has been used extensively in other studies (e.g. Kobelsky, et al., 2008; Chari, et al., 2008; Liu & Ravichandran, 2008). Industry-level data was obtained from the Bureau of Economic Analysis (BEA) and the Bureau of Labor Studies (BLS).

Firm market power, a proxy for firm size, was measured as firm market share, which is the ratio of its sales to industry sales. IT investment was operationalized as IT intensity, and measured as the ratio of a firm's IT expenses to its revenue. Industry growth was measured as the average growth of industry revenues over the preceding three years. Return on assets (ROA) was used as the measure of firm performance. Macro-economic fluctuations were controlled for by including a dummy variable for each of the years in which data was collected.

Analysis and Model

The variables of interest in this study are at both the firm level (performance, size and IT investment) and the industry level (industry growth). Since traditional techniques such as regression are inappropriate for testing cross-level models (Raudenbush & Bryk, 2002), we use hierarchical linear modeling (HLM) to test our hypotheses (e.g. Ang et al., 2002; Levina & Xin, 2007; Mithas et al 2006-7). We used full maximum likelihood (ML) and an empirical Bayes procedure to estimate the model in HLM v. 6.05a (Raudenbush, et al., 2002). ML estimation helps to obtain efficient estimates for unbalanced panels (Raudenbush & Bryk, 2002), similar to the dataset in this study, where the same firms do not appear in all of the years.

The model was estimated in an incremental approach, which allows model testing. First, a fully unconditional model was tested where there were no covariates at either level (Model 1). This helped evaluate whether sufficient variation existed in firm performance. Next, we estimate a random coefficients model, where we add firm-level covariates (Model 2). The significance of the random effects¹ can be assessed by comparing the deviance (-2 log likelihood criterion) between the two nested models, using a χ^2 distribution. The degrees of freedom for this test will be the difference in the number of parameters between the two models.

In the third step, we include industry-level covariates (Model 3), which means that we are allowing slopes and intercepts to vary across industries. Thus, in this level 2 model, the intercepts and slopes of the level 1 model are estimated using industry-level covariates. Partitioning the variance in this way allowed the computation of the intra-class correlation (ICC), which is a measure of the relatedness or dependence of nested data. ICC is equal to $\sigma^2 / \sigma^2 + \tau$, where σ^2 is between-industry variation and τ is within-industry variation. It is worth noting that this paper is focused on estimating the impact of industry growth on a) the IT-firm performance relationship, and b) the moderating effect of firm market-share on the IT-firm performance relationship. Formally, the model is:

Firm-level (within-industry) model

$$Y_{ij} = B0_{ij} + B1_{ij}*(MKTSHR_{ij}) + B2_{ij}*(ITMKTSHR_{ij}) + B3_{ij}*(IT_{ij}) + R$$

Where: Y is the return on assets (ROA) of the *i*th firm in industry *j*;

MKTSHR_{ij} and IT_{ij} denote the market share and IT intensity respectively of the *i*th firm in industry *j*;

ITMKTSHR_{ij} is an interaction term to test

B0_{ij} is the conditional mean performance of all firms in industry *j*;

B1-3_{ij} are the conditional effects (the slopes) of market share, the interaction between market share and IT intensity, and IT intensity respectively for firms in industry *j*

Industry-level (between-industry) model

¹ A fixed effects specification was not appropriate for this study, as it would imply that the results could not be generalized to firms not in the sample.

$$B0 = G00 + G01*(YEAR) + G02*(GROWTH) + U0$$

$$B1 = G10 + G11*(GROWTH)$$

$$B2 = G20 + G21*(GROWTH)$$

$$B3 = G30 + G31*(GROWTH)$$

Where: G00 is the mean return on assets (ROA) of firms in industry j ;

G10-G30 are the mean effects of market share, the interaction between market share and IT intensity, and IT intensity respectively for firms in industry j ,

G11-G31 are the conditional effects (the slopes) of industry growth rate on the impact of market share, the interaction between market share and IT intensity, and IT intensity respectively of firms in industry j

RESULTS

Tables 1a and 1b depict the correlation matrix for the variables. Note that the correlation between industry growth and year changes across levels: it is negative at the firm level and positive at the industry level. This variance in the relationship at different ecological levels is further indication that HLM is an appropriate methodology for this dataset. To reduce multicollinearity, industry growth was centered at its grand mean and firm-level variables were centered at their group means. This implies that the intercept at the firm-level represents the mean ROA for a firm at its average level of IT intensity and market-share across the years, and the average level of industry growth across the entire sample.

	<i>roa</i>	<i>mktshr</i>	<i>it</i>	<i>itmktshr</i>	<i>Growth</i>	<i>Year</i>
<i>roa</i>	1					
<i>mktshr</i>	0.0662966	1				
<i>it</i>	0.0154741	-0.01492	1			
<i>itmktshr</i>	0.0491429	0.5039213	0.5685755	1		
<i>Growth</i>	0.1767748	0.1104163	-0.086709	0.0137216	1	
<i>Year</i>	-0.072826	0.0517468	-0.062207	-0.016017	-0.02976	1

Table 1a: Correlations of Firm-level Variables (n = 1413)

Industry-Level Correlations	
	<i>Growth</i>
<i>Growth</i>	1
<i>Year</i>	0.0832809

Table 1b: Correlation of Industry-level Variables (n = 290)

Table 2 lists the results. The results of the null model (Model 1) point to significant variance in ROA ($\chi^2 = 176.025$, $df = 144$, $p = 0.036$), indicating the need for further analysis. The largest percentage of variation in firm performance lies within industries (93.25%), while a smaller proportion lies across industries (6.75%). Model 2 shows that a firm's market share significantly affects its ROA, which is consistent with prior research. However, a firm's IT intensity and the interaction of its IT intensity with its market share do not affect its ROA. Our hypotheses are tested in Model 3, which includes industry growth. Hypothesis 1, which argues that IT has a stronger impact on firm performance when firms are located within growing industries, is supported ($G31 = 6.671$, $p < .05$). Hypothesis 2 posits that, within growing industries, firms with a smaller market share obtain more value from their IT investments. The interaction between industry growth and IT intensity ($G31$) changes from positive to negative when market share is used to expand that interaction term ($G21$). Thus, Hypothesis 2 is also supported ($G21 = -109.406$, $p < .05$).

Variable	Model 1	Model 2	Model 3
Intercept (G00)	0.0456** (0.006)	0.0364** (0.008)	0.044** (0.009)

Year (G01)	-	-	-0.004* (0.002)
Growth (G02)	-	-	0.143 (0.104)
Firm-level effects:	-		
Market Share (G10)	-	0.1620** (0.051)	0.229** (0.075)
Market Share*IT Intensity (G20)	-	0.2454 (2.293)	-1.749 (2.154)
IT Intensity (G30)	-	0.114 (0.216)	-0.205 (0.212)
Cross-level effects:			
Growth* Market Share (G11)	-	-	0.633 (0.465)
Growth*Market Share*IT Intensity (G21)	-	-	-109.406* (48.65)
Growth*IT Intensity (G31)	-	-	6.671* (3.071)
Deviance (-2 log likelihood)	-949.1814	-955.3922	-977.9395
σ^2	0.01617	0.01605	0.01313
τ	0.00108	0.00118	0.00095
Variance Decomposition			
Across Firms ($ICC = \sigma^2 / (\sigma^2 + \tau)$)	93.74%	93.15%	93.25%
Across Industries (1-ICC)	6.26%	6.85%	6.75%

Table 2: Results of HLM Estimation

** $p < 0.01$, * $p < 0.05$ † $p < 0.10$

Note: the numbers in parentheses are standard errors; the coefficient estimates are before them.

Limitations

The results of this study should be seen in the light of its limitations. First, the *Information Week* data is self-reported, so it may be biased to enhance the reputation of the informant. Second, other variables that have been shown to be significant covariates of IT value could be added as further controls in the analysis. Third, accounting-based measures of firm performance, such as ROA, are prone to managerial manipulation. Thus, the relationships shown here should be tested against other measures of firm performance, such as Tobin's Q. Finally, a generic "IT intensity" measure was used here. In place of this gross measure, future studies should utilize more fine-grained measures of IT, as the relationships found here may differ across different types of IT investments.

DISCUSSION

This study is in line with the call for IS researchers to generate "macro" theories of IT-enabled transformations in different contexts (Agarwal and Lucas, 2005). Identifying some of the primary mechanisms through which IT's impact varies across different contexts is an important task for a number of reasons. For one, it will improve researchers' ability to clarify the IT productivity conundrum- from a lack of value in the 1980s, IT has been found to have "too high" returns now. Perhaps, the use of multi-level models will help separate out the various impacts IT has had in different contexts. Second, it may help improve the targeting of scarce corporate resources when making IT-related investments. Being aware of the pathways through which firms obtain positive benefits from their IT investments should improve managers IT investment decisions.

The results of this study reinforce the argument that IT investments and their impact are contextually determined. By examining the interaction of only three variables, we found some interesting relationships, and it is probable that other, similarly-intriguing relationships will be found when other variables are studied. Since IT has a higher impact on the performance of newer firms in growing industries, it is possible that the often-reported phenomenon of time lags in the realization of IT value may be found only among certain categories of firms. These should include those with substantial legacy investments, which have increased their switching costs. How should existing firms in growing industries resolve this challenge? If they do not, they risk the new entrants to their industry accruing their rents. Since the ultimate goal is firm performance, one option would be for firms to regularly re-evaluate their IT portfolios in terms of their switching costs. IT

assets with lower switching costs should be preferred, as they will help maintain a firm's agility. As further research on other cross-level interactions is carried out, it behooves researchers to share their findings with firms so as to lower the proportion of unnecessary IT investments and increase the value they obtain from those that have.

CONCLUSION

The study is the first to examine how the level of industry growth influences the impact of IT on firm performance, while controlling for aggregation effects and cross-industry variation in IT use. There are two key contributions of this research:

1. Assessing the role of industry-level characteristics, such as growth, in affecting the impact of IT on firm performance; and
2. Presenting a methodology whereby the contingencies that impact the value firms obtain from IT can be assessed.

Given the debate in IS research regarding the impacts of IT, the questions that have gained significance are similar to "when does IT matter?" and "how does IT matter?" This study's results imply that while measuring the impacts of information systems, it is essential to factor in macro- level industry factors, as they influence the impact of IT. Future work on IT value should not neglect the nested nature of firms by using methods that do not take into account multi-level influences. Doing so could lead to incomplete or even misleading results, which could have impacts on the decisions managers make.

Further research could extend this study in two ways. First, additional industry-level variables that are known to influence the impact of IT on firm performance, such as concentration, dynamism, uncertainty, the level of regulation, and the role of IT in the industry (i.e. automate, informate up or down, transform), could be used to uncover additional mechanisms through which firms obtain a payoff from their IT investments.

Second, a third level of analysis could be the wider macro-economic environment firms operate in. Here, the impact of covariates, such as national income (GDP), the inflation rate and educational level, could be used to evaluate whether and how they impact the effect of IT on firm performance. Given the fluctuations in economic growth and inflation over the past decades, it is worth examining if these macro economic variables should be taken into account while establishing the criteria for evaluating IT impact. The ensuing three-level interactions would help identify how firms should harness their IT assets according to conditions in their industry and the wider macro-economy. More importantly, they would lay the base for developing a new process theory of IT value that incorporates the impact of industry- and country-wide attributes. This could be potentially useful in helping improve our explanation of the impacts of IT. By considering contingencies at multiple levels, researchers should be able to help manager's improve their IT investment decisions.

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